will continue to improve as additional technologic innovations result in superior images with lower doses.

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REFERENCES

Feig SA: Low-dose mammography: Assessment of theoretical risk, chap 6, *In* Feig SA, McLelland R (Eds): Breast Carcinoma: Current Diagnosis and Treatment. New York, Masson Pub USA, 1983, pp 69-76

Lester RG: President's address—The contributions of radiology to the diagnosis, management and cure of breast cancer. Radiology 1984 Apr; 151:1-7

Kopans DB, Meyer JE, Sadowsky N: Breast imaging. N Engl J Med 1984 Apr; 310:960-967

Noninvasive Doppler Ultrasonography of Carotid Arteries

THE DEVELOPMENT of Doppler ultrasound has greatly enhanced our ability to diagnose a variety of arterial and venous diseases. To date, one of the primary indications for the use of Doppler ultrasound is in investigating cases of possible extracranial carotid artery occlusive disease. This is often referred to as carotid duplex scanning, which is a combination of high-resolution real-time imaging of the carotid arteries with pulsed Doppler wave form and spectral analysis.

In general, patients with a clear-cut history of transient ischemic attacks or reversible ischemic neurologic deficits are studied primarily with selective carotid angiography. Carotid duplex scanning is generally reserved for screening patients who have either an asymptomatic carotid bruit or an unclear history of a transient ischemic attack. In direct comparison studies with selective angiography, carotid duplex scanning has proved to be a reliable technique in showing significant atherosclerotic stenoses at the carotid bifurcation, with accuracies ranging from approximately 85% to 95%. In fact, some authors claim an increased sensitivity for carotid duplex scanning by its ability to detect relatively small plaques that may go undetected by a study such as angiography, which merely shows intraluminal anatomy rather than direct mural lesions.

Specific Doppler criteria for estimating the extent of stenosis have been established by several authors using either a ratio of maximal peak systolic internal carotid flow velocity to maximal common carotid peak systolic flow velocity or using the overall quantitative peak frequency shift obtained within the internal carotid. In persons with normal anatomy, there are both characteristic sounds and wave forms of the internal carotid, external carotid and common carotid arteries. One of the great advantages of carotid duplex scanning is that it combines both anatomic information by virtue of high-resolution real time with the ability to diagnose physiologic disturbances and blood flow with pulsed wave form Doppler analysis. Approximately 10% of carotid bifurcations cannot be adequately imaged with carotid duplex scanning because of a high cervical location of the bifurcation.

One of the major limitations of carotid duplex scanning is that it is operator-dependent. It requires significant experience and commitment to mastering this technique to achieve good results. In experienced hands, however, it is a relatively rapid, noninvasive and inexpensive method of evaluating the carotid bifurcation for significant atheromatous stenoses. To date, the sensitivity for carotid duplex scanning in diagnosing ulcerations is not known, however, because of the inherent tomographic nature of this technique; partial voluming of an irregularly surfaced plaque may lead to misdiagnosis. Because of the ability of carotid duplex scanning to directly image a plaque, in some instances it is possible to characterize the histologic features of a plaque by its sonographic appearance. Calcified plaques produce areas of high-amplitude echoes with acoustic shadowing. Intraplaque hemorrhage has received a greal deal of interest in the surgical literature and may be responsible for significant neurologic symptoms, as platelet-aggregate emboli may ensue. Early reports suggest that carotid duplex scanning may have a role in the diagnosis of intraplaque hemorrhage, indicating a biologically unstable plaque even in the absence of a hemodynamically significant stenosis.

When compared with other less invasive techniques such as intravenous digital subtraction angiography, carotid duplex scanning has a number of distinct advantages. First, it is not dependent on patient motion or cardiac output. Second, it is completely noninvasive and does not involve intravenous administration of any contrast media. Third, it is significantly less expensive and often less time consuming. In summary, carotid duplex scanning has proved to be a reliable and clinically useful technique in experienced hands in evaluating significant carotid bifurcation disease.

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REFERENCES

Dreisbach JN, Seibert CE, Smazal SF, et al: Duplex sonography in the evaluation of carotid artery disease. AJNR 1983 May-Jun; 4:678-680

Garth KE, Carrol BA, Sommer FG, et al: Duplex ultrasound scanning of the carotid arteries with velocity spectrum analysis. Radiology 1983 Jun; 147:823-827

Roederer GO, Langlois YE, Jager KA, et al: The natural history of carotid arterial disease in asymptomatic patients with cervical bruits. Stroke 1984 Jul-Aug; 15:605-613

Magnetic Resonance Imaging

EXPERIENCE WITH the use of magnetic resonance (MR) imaging for clinical diagnosis has been ongoing for more than three years at several centers in the United States and in Great Britain. It is now clear that MR imaging will assume an important place in clinical diagnosis and biomedical research. It has the following distinct advantages: soft tissue contrast resolution far exceeding the limits of computed tomography (CT) and ultrasonography, absence of possible mutagenic effects inherent with ionizing radiation, unequivocal blood pool identification without the need for contrast media and direct imaging in multiple planes (coronal, sagittal, transverse).

These diagnostic advantages have already been recognized for imaging of four parts of the body. MR imaging is the procedure of choice for most purposes in evaluating the central nervous system (CNS), including the spinal cord. Among its advantages are definitively diagnosing leukoencephalopathies such as multiple sclerosis, greater sensitivity for defining brain lesions compared with using CT, improved depiction of lesions in the posterior fossa through sagittal images and freedom from bony artifacts and visualizing the spinal cord without contrast media and discriminating various pathologies within the cord itself.

The natural contrast between the blood pool and cardiovascular structures makes it valuable for cardiovascular imaging. Recent studies have shown its accuracy for the completely noninvasive evaluation of aortic aneurysms and dissections; tumor and bland thrombi within cardiac cham-

bers, arteries and veins; intracardiac and paracardiac masses; presence, site and complications of myocardial infarctions; constrictive pericarditis; hypertrophic cardiomyopathies, and congenital heart disease. Recent reports have indicated its capability for directly visualizing acutely infarcted myocardium and differentiating infarcted from normal myocardial tissue.

High-contrast resolution and multiplanar image acquisition make MR imaging an important modality for imaging of the pelvis, including the diagnosis and staging of prostate, bladder and gynecologic tumors. The sharp discrimination of endometrial and myometrial layers provides the capability to evaluate focal, small tumors and to assess response to oncotherapy and hormonal interventions. Accuracy for the early diagnosis of renal transplant rejection has been shown.

Musculoskeletal applications are now becoming evident: early identification of avascular necrosis, the medullary extent of bone tumors and lumbosacral disc disease. The recent introduction of thinner tomograms (2.5 mm) extends the uses of MR imaging for evaluating disc disease.

The enormous potential of MR imaging has been clearly evident in the first years of clinical operation. The future role is probably underestimated, however, since MR imaging is being compared with other modalities at a time when it is still an immature and rapidly evolving technology.

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REFERENCES

Brant-Zawadzki M, Norman D, Newton TH, et al: Magnetic resonance of the brain: The optimal screening technique. Radiology 1984 Jul; 152:71-77

Hricak H, Peduska N, Terrier F, et al: Workshop November 25, 1984: The potential of MR imaging in post-transparent renal failure. Radiology 1984; 153:59

Margulis AR, Higgins CB, Kaufman L, et al: Clinical Magnetic Resonance Imaging. San Francisco, Radiology Research and Education Foundation, 1983

McNamara MT, Higgins CB, Schechtmann N, et al: Detection and characterization of acute myocardial infarction in man with use of gated magnetic resonance. Circulation 1985 Apr; 71:717-724

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